Summary

Near-surface velocity gradients and their effect on shallow reflection data in the vadose zone and the bedrock surface or the piezometric surface of about 9 ft (Birkelo et al., 1987). In settings like this where the average velocity rapidly changes within a very short travel time a 250 Hz reflection wavelet will interfere with any reflection arrival from interfaces less than 20 ft beneath it. Estimations of vertical bed resolution based on 1/4 wavelength criteria using a single velocity would be in error in this setting. In the physical setting previously described (Birkelo et al., 1987), if the extreme change in velocity is considered (velocity gradient), 250 Hz data should provide about a 5 ft theoretical vertical resolution (1/4 wavelength), while estimating the resolution potential using only the velocity of the shallow 250 Hz reflection a resolution potential of 1.3 ft would be calculated.

Stacking velocities have traditionally been determined for 2-D reflection surveys using constant velocity stacks, curve fitting to shot gathers, or semblance routines (Yilmaz, 1987). The use of these techniques to determine appropriate stacking velocities for a series of shallow reflecting layers in an area with an extreme vertical velocity gradient will not allow easy discrimination of artifacts in or sufficient insight into the accuracy of resulting stacked sections. The error in the NMO correction process becomes more obvious as the velocity gradient increases. The error or distortion is the result of defining a time varying velocity function for a reflection wavelet of finite length and constant velocity. Any portion of the wavelet extending above or below a specific time where the stacking velocity of that wave-
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let is defined will be distorted relative to the vertical rate of change of the time-varying velocity function. The process of generating an accurate stacked waveform in settings with abrupt changes in the near-surface velocity is complicated when relatively small static anomalies (on the order of a couple msc) having lateral extent consistent with or smaller than the length of the spread are present.

Dramatic changes in near-surface velocity are not a concern in all unconsolidated settings where depth to the piezometric surface is at least 10 ft deep (Figure 1). A shot gather from the Mississippi River Valley in Minnesota shows a prominent low velocity reflection with several high frequency, significantly higher velocity reflections at longer offsets and greater times (Figure 1A). Water table at this site is around 20 ft. Contrasted with that is the field file from the Monterey Bay area of California which possesses a water table of about 80 ft and a near-surface geology dominated by dune sand deposits (Figure 1B). The reflection events on this shot gather have very unique curvatures consistent with a well behaved velocity function. The shot gather from near Henderson, Nevada, possesses a couple of very low velocity reflections (Figure 1C). This very difficult reflection area has a water table about 10 ft deep and a sandy near-surface. Very high signal-to-noise ratio shot gathers were recorded in the Atlantic Coastal Plain in eastern North Carolina (Figure 1 D). The water table there is at about 15 ft with the near-surface predominantly alluvial sediments. The extremely high quality reflection events define a very well behaved gradually increasing velocity function. Clearly, of the four shot gathers displayed here, all with similar lithologies and saturation char-
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characteristics, only the one from Minnesota possesses a dramatic vertical velocity gradient.

Applying the NM0 correction as dictated by a velocity function defining an extremely large velocity gradient will result in degradation of the spectral properties of the reflection wavelet, incorrect apparent zero offset reflection time, and in some cases high frequency artifacts (Figure 2B). Compounding the problems for shallow reflection data sets is the need for a very low allowed percent stretch ratio (Miller, 1992). When a reasonable stretch mute (17%) for shallow reflection data is accompanied by a complete velocity function, all reflection arrivals are muted below the defined high velocity contrast (Figure 2B). If the stretch mute is relaxed to around 100%, the entire suite of shallow reflections are present and moved out, but obvious distortion is evident within the portion of the section possessing the extremely high velocity gradient (Figure 3A). A potentially significant problem with data corrected with this large a stretch mute are the artifacts generated by the inversion and compression of the longer offset wavelets. These artifacts are more evident on shot gathers
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that have been first arrival muted (Figure 3B). Structural features or static anomalies on the shallow low velocity reflection curve dramatically alter the effectiveness and completeness of the moveout correction (Figure 4). Using an appropriate velocity function for this curve demonstrates the potential degradation of stacked reflection wavelets in areas with moderate structural features.

Conclusions

Extremely similar unconsolidated near-surface lithologies with alternating sands and clays and relatively shallow water tables can be represented by dramatically different velocity functions. In some settings, due to the extreme velocity contrast at the piezometric surface, the velocity gradient may not allow corrections for non-vertical incidence to be performed on reflections above and below this surface within the same processing pass. Artifacts that could easily go undetected under “normal” processing flows and procedures could result in inaccurate, misleading, and potentially devastating interpretations.

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References


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